

Aroma Volatile Differences in Commercial Orange-fleshed Cantaloupes, the Inbred Parental Lines and Stored Fresh-cuts

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Abstract

Substantial differences exist in muskmelons regarding flavor and fresh-cut processing quality. We are attempting to discriminate volatile compounds that can be used as reliable breeding indicators for melon quality. Analysis of commercially available cultivars and their male and female inbred breeding lines may indicate hereditary linkages and help pinpoint desirable flavor attributes. Cantaloupes were grown commercially on raised beds with standard cultural practices and furrow irrigation. 'Athena' and 'Sol Real' fruit and both homozygous parental male and female breeding lines were harvested (3/4-slip) in early summer or fall and analyzed for volatiles. Cubes from numerous fruit per cultivar were randomized and roughly 300 g was placed into 24 ounce clamshell containers that were stored at 4 °C. Volatiles were determined in rapidly homogenized juice via solid phase microextraction (SPME) by GC-MS. Commercial and male lines often had substantially higher esters ($R-(C=O)-O-R_{\text{alcohol}}$) and S-compounds, whereas females generally had higher acetate esters ($CH_3-(C=O)-O-R_{\text{alcohol}}$) and aldehydes. Cantaloupes harvested in fall generally have inferior quality compared with the summer season, and inconsistencies in fall volatile trends were also apparent. Results indicate that distribution of key desirable volatile compounds may be related to male versus female inheritance. More commercial cultivars and parental breeding lines need to be investigated and statistically analyzed to ascertain if these relationships are authentic.

INTRODUCTION

Orange-fleshed cantaloupes are highly regarded for their unique flavor and high sugar levels are often the determinant of quality (Yamaguchi et al., 1977). Consumer acceptance of melons is driven most often by sweetness (sucrose) (Bianco and Pratt, 1977) and also by an acceptable aroma bouquet or presence of volatiles. However, soluble solids (SS) are only partially correlated with sweetness (Mutton et al., 1981; Yamaguchi et al., 1977) and high SS alone does not appear to adequately define "good melon quality" (Aulenbach and Worthington, 1974; Currence and Larson, 1941; Mutton et al., 1981). Fruit harvested before development of the abscission zone will not develop flavor and volatiles similar to fruit that remained on the vine until fully ripe (Beaulieu and Grimm, 2001; Pratt, 1971; Wyllie et al., 1996). Soluble solids content is often the only reliable, easily measured quality assessment for determination of optimum muskmelon harvest. Other non-destructive harvest indicators such as ground color change, size, degree of netting and dehiscence (slip) can fluctuate due to local environmental variation, irrigation before harvest and season (Anonymous, 2000; Pardossi et al., 2000).

With uniform 3/4-slip harvested fruit, mean comparisons conducted based on the sex of the parent indicated that female lines had significantly lower glucose, fructose, sucrose and total sugars than the commercial lines, and commercial means were significantly higher than the male and female means for all sugars, except glucose (Beaulieu et al., 2003). Information regarding genetic control of important volatile genesis, as related to male or female inbred parental lines or production region and season, is still lacking. Research reports geared toward understanding mechanisms

responsible for generation and/or loss of flavor and textural quality in cut fruits are also limited. Fresh-cut volatile assessment of two commercial cantaloupe cultivars and their inbred male and female lines was therefore performed to determine if differences could be correlated with, or ascribed to parental lineage or melon type/growing region.

MATERIALS AND METHODS

Two cantaloupe (*Cucumis melo* var. *reticulatus*) cultivars; 'Athena' (A), an "eastern" melon, and 'Sol Real' (SR), a "western shipper", and both homozygous inbred male (M) and female (F) parental breeding lines were analyzed over three seasons. The six cultivars were grown on commercial raised beds with standard cultural practices and furrow irrigation near Yuma, Arizona, in spring 2000 and 2001 and in Woodland, California in summer 2000. All fruit were harvested at precisely $\frac{3}{4}$ -slip, field hydro-cooled, and shipped next day to the SRRC, washed in 5.25% NaOCl, peeled on a Muro CP-44 peeler then fresh-cut into cubes (Fig. 1). Cubes (300 g) from a representative pool of 5 to 6 fruit were placed into 24 ounce (~1 liter) low profile clamshell containers (n=3) and stored at 4 °C for assessment after 0, 3, 5, 7, 10, 12 and 14 d.

After storage, cubes were rapidly (~15 s) juiced into a slurry and automated headspace volatile analysis was performed via SPME, GC-MS (HP 6890/5973) according to Beaulieu and Grimm (2001). Briefly, 3 ml slurry (no foam) was pipetted into 10 ml glass vials containing 1.1 g NaCl, then an internal standard (2-methylbutyl 3-methylbutanoate) and vials were sealed with a Teflon/silicon septum, placed on a Combi-Pal Autosampler (Leap Technologies, Carrboro, North Carolina) cooling rack at 4 °C, and analyzed within 12 hr. Data were collected with HP ChemStation software (A.03.00), searched against the Wiley (7th edition) registry of mass spectral data and confirmed by standards. Volatiles presented (with sensory attributes in parenthesis) are based on muskmelon compounds reported to be aroma- or flavor-important in the literature and termed Critical Flavor Compounds (CFC's).

A completely randomized design with a two-way treatment structure of six cultivar levels (A, A-M, A-F, SR, SR-M and SR-F) and three seasons (summer 2000 & 2001, fall 2000) was used. Averaged volatile profiles (n=3) are preliminary and not processed statistically.

RESULTS AND DISCUSSION

In general, the relative abundance for target ion response trends were seasonal, with summer 2000 > summer 2001 > fall 2000 (Fig. 2 - 4). Fall data often did not follow similar trends compared with summer data but apparent inconsistencies in fall trends are not surprising because fall-harvested fruit generally have inferior postharvest qualities compared with the summer season. Although relative ion responses over seasons varied for most compounds, general trends were followed for many esters, acetates, aldehydes and S-compounds.

Commercial cultivars and male lines, especially 'Sol Real', had the highest abundance of esters ($R-(C=O)-O-R_{\text{alcohol}}$) such as methyl and ethyl 2-methyl butanoate that are considered flavor (fruity, sweet, apple, pungent) important (Fig. 2). Throughout storage, the ester volatile recovery per cultivar was generally male > commercial > female. The western cultivar, 'Sol Real', normally had higher ester levels compared with the eastern cultivar, 'Athena'. Many other esters recovered, but not considered CFC's in cantaloupe, also displayed this trend (data not shown). On the other hand, acetate esters ($CH_3-(C=O)-O-R_{\text{alcohol}}$) such as 2-methyl 1-butyl acetate (fruity, banana, citrus) and hexyl acetate (apple, cherry, pear, floral) were often highest in the commercial cultivars or their female parents (e.g. Fig. 3). However, there appeared to be variability in some acetates recovered concerning whether the female or male lines were most abundant through storage, especially in the fall 2000 season.

Sulfur compounds (e.g. ethyl (methylthio) acetate) in 'Sol Real', A-F and SR-F in all 3 seasons were almost absent, whereas the A-M, SR-M and 'Athena' had similar patterns, with the highest levels (Fig. 4). A typical CFC aldehyde, (Z) 6-nonenal (melon,

citrus), was generally higher in females compared with males and commercial cultivars. The SR-M was lowest; almost non-existent, and fall trends were again inconsistent (Fig. 4). Almost identical patterns were observed for another CFC aldehyde (*E,Z*) 2,6-nonadienal (cucumber, green, waxy) (data not shown). Although certain aldehydes are considered CFC's within *Cucumis*, excessive concentrations may be perceived as green, fatty or waxy. Hence, choosing female lines for breeding may be an important consideration to minimize potentially undesirable aromas/flavors. In general, transient volatile increases, often followed by gradual declines occurred in several compounds. Yet, occasionally compound recovery gradually increased throughout storage, and we are attempting to understand these peculiar phenomena.

CONCLUSION

In numerous fresh-cut fruit storage studies, we have observed transient increases in volatiles (Beaulieu and Baldwin, 2002; Beaulieu and Lea, 2003) and sensory aroma/flavor attributes (Bett et al., 2003), followed by a general decline. Increased oxygen permeability and oxidation at the exposed surface may facilitate increased alcohol production and acid imbalances leading to esterification, and LOX-generated backbone compounds which recycle substrates leading to additional volatile synthesis. Increased production and/or off-gassing for certain esters may then occur. Subsequently, upsetting the unique balance of CFC's through cutting and storage could negatively affect flavor and the consumer's perception of desirable attributes. More research is needed to understand these phenomena.

Results indicate that parental inheritance may be related to the distribution of key, desirable volatile compounds in commercial cultivars. Commercial and male lines often had substantially higher esters and S-compounds whereas females generally had higher acetates and aldehydes. There also appears to be an interesting difference between ester accumulation in western fruit versus acetate accumulation in eastern fruit. More commercial cultivars and parental breeding lines need to be investigated and statistically analyzed to ascertain if these relationships are authentic.

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Figures

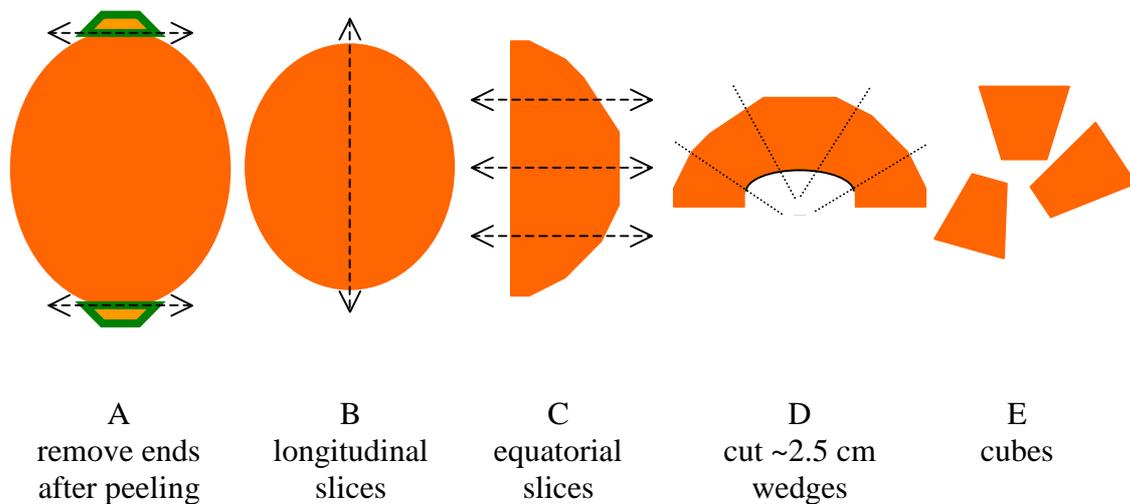


Fig. 1. Preparation of fresh-cut cantaloupe cubes (E) immediately after peeling (A) on a Muro CP-44. Dotted lines (A, B, C and D) indicate a cut made with sharp knives after initial peeling. All loose adhering internal (cavity) endocarp tissue (D) was also removed (1 - 2 mm) with a sharp paring knife.

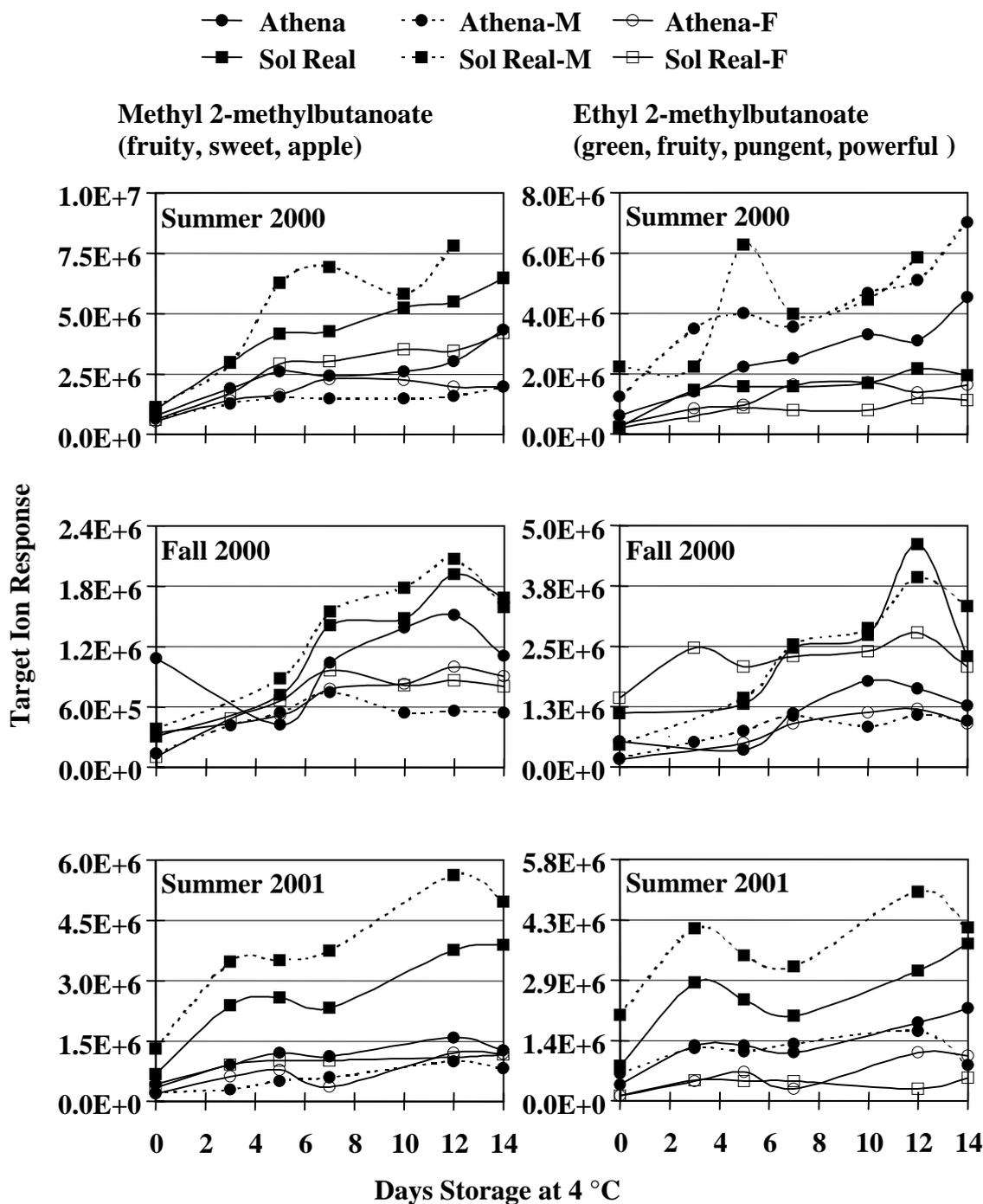


Fig. 2. Volatile differences (SPME, GC-MS) in typical esters in fresh-cut cantaloupes and their inbred parental lines during storage in clamshell containers (n=3).

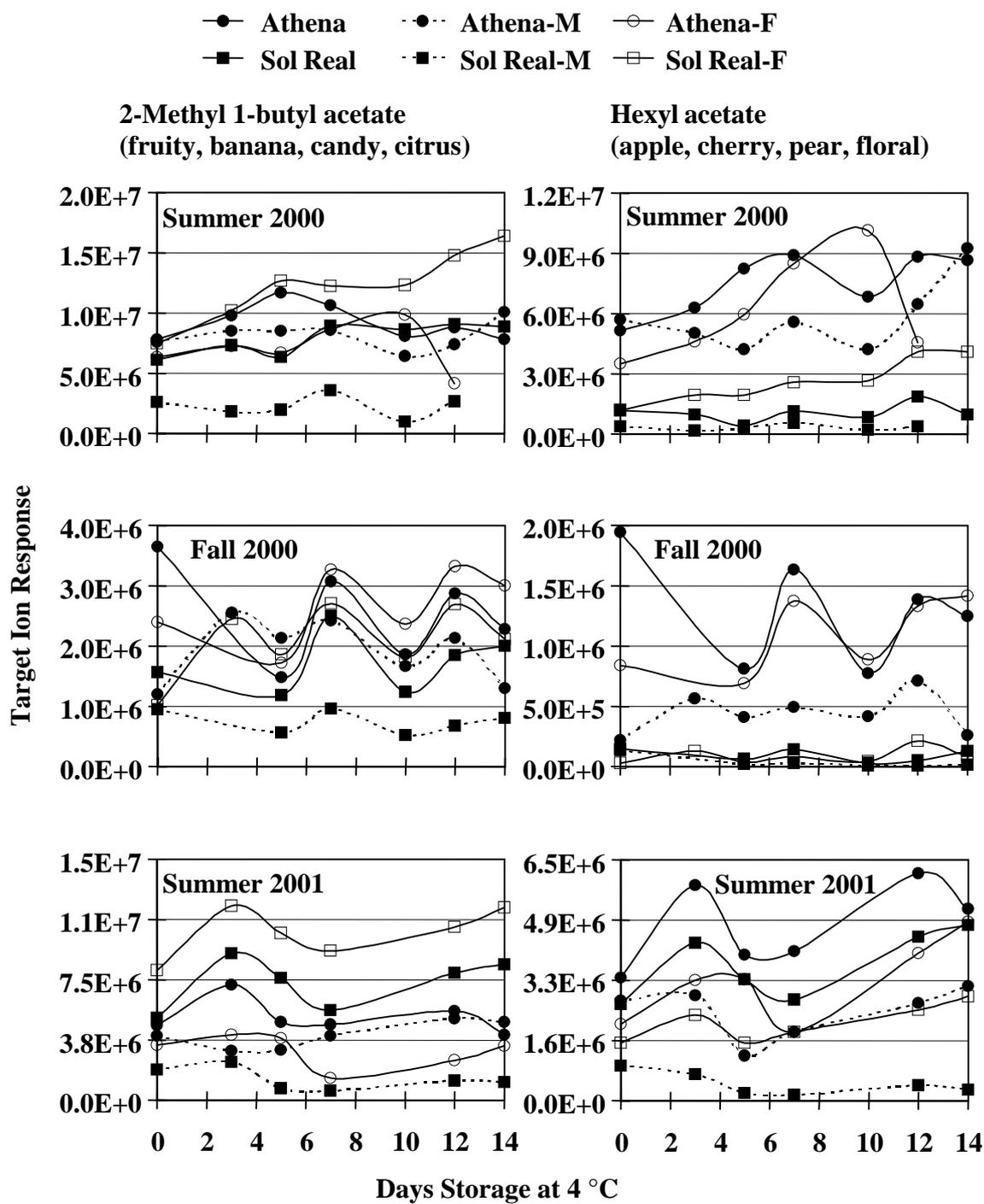


Fig. 3. Volatile differences (SPME, GC-MS) in typical acetates in fresh-cut cantaloupes and their inbred parental lines during storage in clamshell containers (n =3).

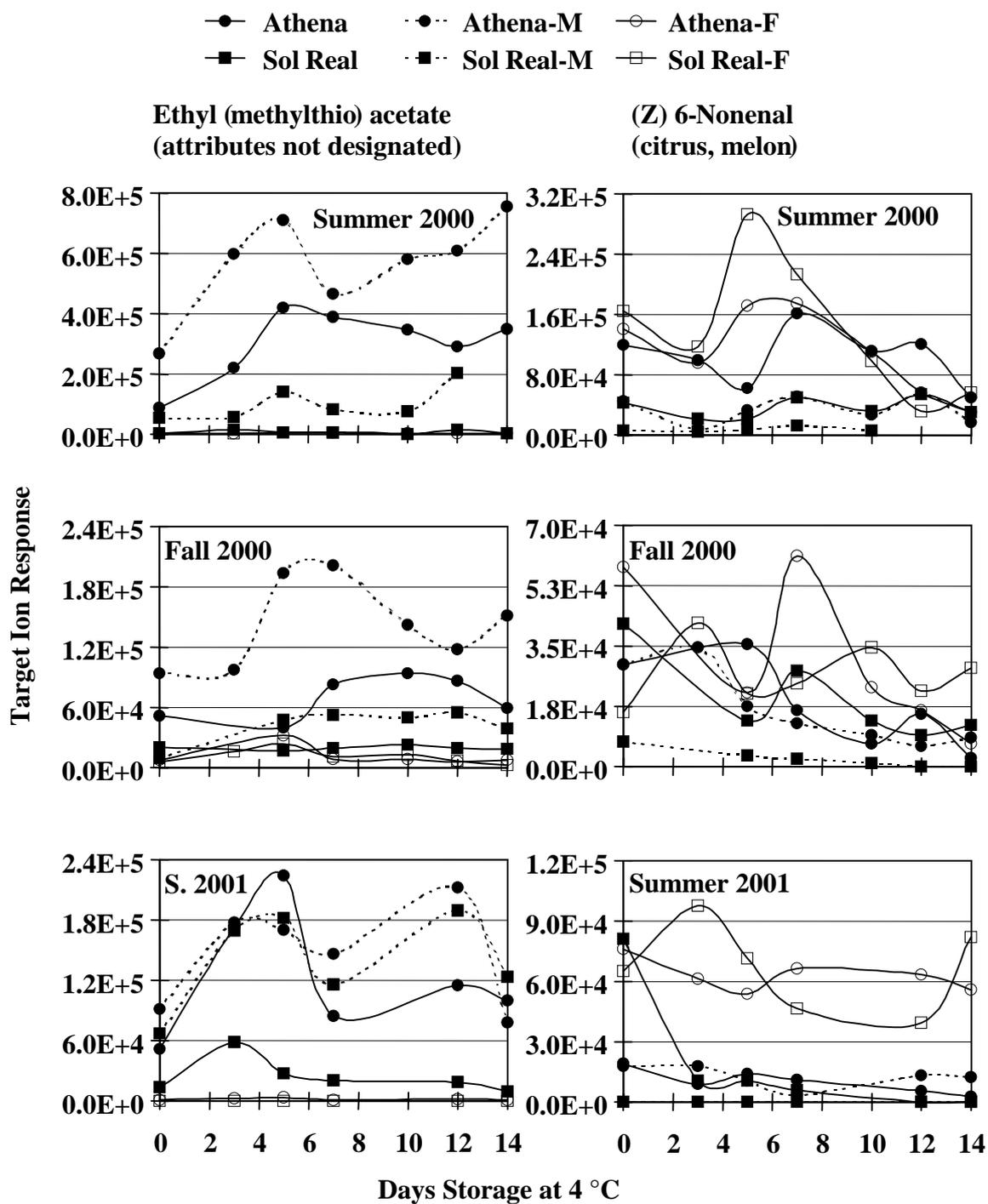


Fig. 4. Volatile differences (SPME, GC-MS) in typical thio and aldehyde compounds in fresh-cut cantaloupes and their inbred lines during storage in clamshells (n=3).